NOTE ON THE ATMOSPHERIC CONDITIONS REQUIRED FOR ASTRONOMICAL OBSERVATIONS.

By John Evershed.

In an interesting article on this subject in the *Publications* of the Astronomical Society of the Pacific, No. 158, April, 1915, Dr. Campbell very kindly refers to my observations in Kashmir, giving an abstract of the Kodaikanal Bulletin, No. 42, in which I contrast the conditions on the valley-floor of Kashmir with those on the mountain-top at Kodaikanal. In this bulletin I showed that, owing to the absence of convection currents which are so ruinous to good definition, the conditions for solar observation are very greatly superior in the valley compared with the mountain-top. Dr. Campbell, however, asks for information as to the night conditions on the mountain-top.

I am very glad of this opportunity to discuss the climate of Kodaikanal, because I consider that my experiences point to the urgent necessity of further research in order to discover the best possible sites for future observatories, and the results of my observations make me very hopeful that vastly better conditions are actually available than those which have hitherto been considered the best.

At Kodaikanal very little night observation is done, but such work as the photography of comets and their spectra, or occasional observation of planetary markings, has left a distinctly unfavorable impression. The climate is a moist one, with a mean annual rainfall of about 60 inches. Roughly speaking, there is a dry and a wet season, that is to say, dry spells of weather may be expected during the months January to April inclusive, whilst fine mornings are prevalent also in December and May. The remaining six months, June-November, are dominated by monsoon conditions, and are usually wet, cloudy, and windy, with occasional breaks of finer weather. When the monsoon is of normal intensity, observing conditions day or night are hopelessly bad. One may, nevertheless, obtain almost

daily photographs of the Sun during this season, if a continuous watch is kept and advantage taken of the least opening in the pall of cloud; but such photographs are of no great value, owing to poor definition. There is usually some amelioration of these conditions in the month of September, when the general direction of the monsoon winds is changing from southwest to northeast.

In the dry season, and during spells of clear dry weather, the night definition is generally very good as observed with a 6-inch telescope. I do not remember, however, to have ever seen such perfect definition as Prof. W. H. PICKERING describes at his station in Jamaica. I believe that, with high power, star-images generally show some slight fluctuations, but critical tests with large telescopes have not been made.

For ordinary photography of comets, etc., the dry spells are almost ideal for transparency, and during such times the sky in the daytime is of a deep blue color right up to the Sun's limb and down to the horizon. Unfortunately we do not get more than two or three such spells during a dry season, each perhaps lasting a week or ten days.

The less favorable weather during the dry season is characterized by the prevalence of thin streaky cloud at a high elevation. This has a strong tendency to form immediately over the mountain mass, the sky over the adjacent plains being often quite clear. This diffusive sky is a great hindrance to all spectrographic work, day or night. There is also much condensation of cumulus cloud during the mornings, and this frequently develops in the afternoon, producing thunderstorms and heavy rain. If it clears at nightfall, observations are greatly interfered with by moisture and by thin clouds condensing and re-evaporating in the most exasperating way, often precisely at the position of some comet or other interesting object one is attempting to observe.[1]

It appears to me that the periodical long-continued atmospheric disturbances due to the monsoon currents are the bane of tropical stations; at any rate this is emphatically the case in

[1] In going over our records, I find that of seven bright comets which have appeared in the period 1907-1911 inclusive two only appeared in the dry season, and of these Halley's comet is the only one which could be photographed under really good conditions, during April and the early part of May, 1910.

these longitudes, and far drier and calmer conditions would certainly be found in higher latitudes, as for instance in the two desert belts of the Earth between parallels of 20° and 30° north and south. I do not, however, recommend a location in actual desert regions, where many obvious disadvantages would outweigh the advantage of clear skies; but I consider the ideal locality would be on an oceanic island situated in one of these belts, and for solar work the smaller the island and the greater the extent of the surrounding ocean the better. Everyone who has traveled much by sea will call to mind the remarkable uniformity in the temperature conditions over the ocean. The diurnal range of temperature is much smaller than on land, and in calm weather there is nothing to produce sharp contrasts of temperature. The Sun has very little heating effect on the sea, the energy of the solar rays being absorbed in producing evaporation. The result must be that the normal temperature gradient in the air over the sea is far more uniform than over the land, where strongly heated surfaces produce violent convection currents, more especially in broken mountainous country.

The remarkable experience I have had of excellent solar definition near to the sea in New Zealand and Southwest Australia, and also I may add on a small island a few yards across in the middle of an extensive lake in the Kashmir Valley, tends to confirm the conclusion that an extensive water surface should be favorable to good definition, and I am now able to supplement these observations by reports of the solar definition carried out during several months by Mr. GIBBS, of Nelson, New Zealand, at the coast station selected by me for the Cawthron Observatory. Mr. GIBBS reports that during the typical winter weather with very light sea-breezes during the day the definition on a scale of 5 ranges between 4, 4½, and 5, practically from dawn to dark. Such a state of things is absolutely undreamed of at hill stations, and Mr. CAWTHRON is greatly to be congratulated on the splendid opportunity for utilizing such conditions. Mr. GIBBS further states that when the wind is strong and from the southwest, or still worse from the southeast, definition is bad. These winds at Nelson are off the land. It appears clear, therefore, that when the wind is

gentle and off the sea it brings in the remarkably uniform temperature conditions which must obtain over the ocean. Probably the great contrast of temperature conditions over the sea and over the land would cause extensive atmospheric disturbances and poor definition at continental coast stations; on islands, however, such disturbances would be insignificant, and the conditions would approximate to the uniformity over oceans.

That the latitude of the island has not much effect on this question of definition appears to be indicated by a report I have just received from Rev. A. L. CORTIE, S. J., who observed the total eclipse of the Sun of August 21, 1914, from the small island of Hernosand on the Baltic. He writes that with a southeast wind, *i. e.* a wind blowing across 150 or 200 miles of sea, "the solar definition is practically perfect."

After these experiences it is not at all surprising to read that at Mandeville in Jamaica "the Moon is as clearly seen as if our atmosphere were entirely removed," while "it is doubtful whether any portion of the civilized world can furnish poorer seeing than is usually found in our Eastern States." Is it not worth considering whether this good definition may be due to the uniformity of temperature gradients over the sea in the neighborhood of Jamaica, and that the bad definition found in the Eastern States of America is due to violent atmospheric convection set up by irregular heating of the ground over mountains and plains, and to the contrast of conditions over the continental land-mass and the adjacent Atlantic Ocean?

It appears to me probable that over an enormously extended land-mass uniformity of temperature gradients can scarcely ever be realized, whereas over extended oceans, where the solar rays have so little heating effect, and there are no irregularities of surface, uniformity would be the rule. I consider that it would be well worth while to organize a visit to some of the Pacific Islands, with the special object of observing the definition both day and night. The innumerable islands both north and south of the equator in this ocean afford ample opportunity for selecting a site in a latitude where clear skies

are prevalent. I shall never cease to regret having had no telescope to take ashore when I visited Hawaii in 1906. I shall certainly take the first opportunity that occurs to test the solar definition on a small oceanic island.

KODAIKANAL, June 15, 1915.

AN ERROR IN RADIAL VELOCITY OBSERVATIONS ARISING FROM NON-UNIFORM SLIT ILLUMINATION.

BY REYNOLD K. YOUNG.

It has been a common experience with radial velocity observers to obtain spectrograms giving unaccountably large residuals. For a three prism instrument the probable error of measurement as determined from the agreement of the lines is certainly less than one-half a kilometer and often as small as one or two-tenths, while the mean result may be in error by as much as three kilometers. For a one-prism instrument the probable error of measurement of a late type star is less than one kilometer, yet plates have been found which give velocities as much as ten kilometers from the truth.

These large errors have been ascribed sometimes to changes within the star, sometimes to flexure or temperature effects of the spectrograph and sometimes to the guiding or non-uniform illumination of the slit. Some results obtained here recently from plates taken with a one-prism spectrograph seem to indicate that the major portion of such errors may be ascribed to the latter cause.

On June 1st two plates were taken of *α Boötis*. For the first, the image was held on the south edge of the slit and for the second on the north edge. This procedure was followed purposely to ascertain if it were possible to produce different velocities by the method of guiding. Both plates are weak in the violet but there is no doubt that there is a relative